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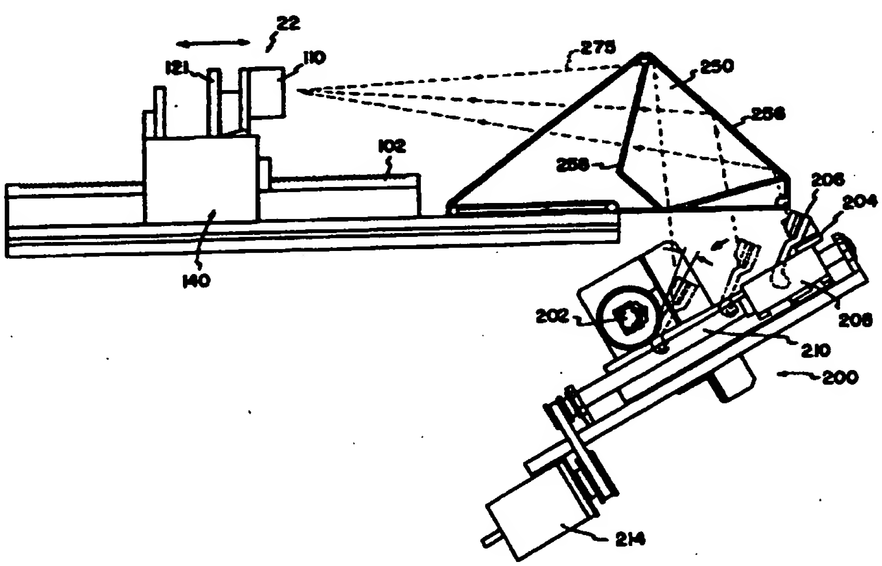

(57) Abstract

The present invention provides an optical system operable in eliminating parallax distortion in a captured image. Specifically, the apparatus eliminates parallax distortion in a palm print image. The apparatus includes a prism having a receiving surface and an object surface. A palm is placed on the receiving surface and a light illuminates the receiving surface so that an image representative of the palm is propagated from the object surface. The propagated image includes a plurality of segments. A lens selectively magnifies each of the segments by a different amount, as to create a plurality of magnified segments of equal length. A image recording medium then captures the magnified segments. The invention also provides a cylindrical device operable in capturing the image of the palm, where the palm may be rolled across a transparent cylinder and reflected light is captured by a recording medium representative of the palm print.

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PALM PRINTER

Field of the Invention

The present invention relates to a method and apparatus for optically eliminating parallax distortion in an image including a method and apparatus for processing skin pattern images representative of a palm print.

Background of the Invention

Parallax in optics describes the situation when the apparent relative orientation of objects changes when the position from which the objects are viewed changes. Parallax causes a condition generally known as keystone distortion, which describes the situation in which different portions of an image appear disproportionate. Parallax distortion must be addressed when capturing an image with a prism. Apparatus which capture images with a prism include finger print capturing apparatus.

In recent years, many law enforcement agencies have turned to devices which optically process and digitize fingerprint images as opposed to using ink and rolling the fingerprint. Two apparatus and methods which are commonly used by law enforcement agencies are disclosed in commonly assigned U.S. Patent Nos. 4,933,976 and 5,230,025.

United States Patent No. 4,933,976 discloses a method for generating data characteristic of a rolled finger print in real time. The method includes the steps of storing arrays of digital data characteristic of a fingerprint and generating a composite array of digital data characteristic of a rolled fingerprint image. The device of United States Patent No. 4,933,976 includes a prism, which utilizes the principle of total internal reflection to capture the image of a fingerprint, a video camera, a frame digitizer and a processor.

United States Patent No. 5,230,025 also discloses a method for generating data characteristic of a rolled fingerprint. The device of United States Patent No. 5,230,025 also includes a prism, which utilizes the principle of total internal reflection to capture the image of a fingerprint, a video camera, a frame digitizer and a processor. However, the method of United States Patent No. 5,230,025 includes the steps of continuously recording images as a finger rolls across the prism and converting those images into digital signals.

Both United States Patent Nos. 4,933,976 and 5,230,025 utilize CCD arrays to capture a pattern of light reflected through the prism when the finger is placed upon a surface of the prism. The CCD array of both United States Patent Nos. 4,933,976 and 5,230,025 are two dimensional CCD arrays, for example, 768 x 960 array. Through the use of a lens and mirrors, the image of the fingerprint is focused onto the CCD array so that the image of the fingerprint may be captured.

Many foreign countries, including Japan, as well as many private organizations (such as, corporations desiring high security) desire devices which optically capture the image of a palm print, in addition to the image of a finger print. A palm print is desirable because, for example, it includes approximately 17 times the data contained on a fingerprint. Also, palm prints are often left at crime scenes.

Some countries, including Saudi Arabia, regularly take a palm print when processing an individual who has been arrested. The methods currently employed in Saudi Arabia and other foreign countries, include the use of ink and are difficult to administer. The greater volume of data associated with the palm is beneficial in categorizing individuals and comparing different palm print images to determine whether there

is a match. In fact, it is estimated that up to one-third of all criminal identifications are made in part on the basis of a palm print.

The CCD arrays and lens of both United States Patent Nos. 4,933,976 and 5,230,025 have an associated resolution sufficient to provide detailed images of the patterns of the fingerprint. The CCD arrays associated with the devices of the prior art are capable only of providing the desired resolution for a fixed surface area of the prism. This fixed surface area is approximately four times the size of an ordinary fingerprint. Significant problems are presented in merely increasing the size of the prisms and the other equipment disclosed in United States Patent Nos. 4,933,976 or 5,230,025 in order to capture the image of a palm print. These problems are related to parallax distortion, resolution, and lighting.

A problem associated with any optical system which, for example, captures an image, such as a fingerprint or palm print through the utilization of a prism, is parallax distortion, and in particular keystone distortion. Specifically, keystone distortion describes the condition when the top of a image is disproportionately narrower or wider than the bottom portion of an image. Keystone distortion is directly related to parallax.

Parallax distortion is created because the object, in this case one surface of the prism, is slanted relative to the other surfaces. Because of the slant, the image focused through the lens will also be slanted. The slanted image can be focused onto a vertical CCD array (i.e., one that is not slanted) if the depth of field associated with the lens the image is being focused through is great enough. Depth of field describes the distance toward and away from the focal point of the lens in which clear focus is available. It is well known that depth of field is a function of the

f-stop, or the size of the aperture of the lens. As the f-stop increases, that is as the aperture becomes smaller, the depth of field becomes greater. Similarly, as the f-stop decreases the depth of field becomes less. Additionally, as the f-stop increases so does the amount of light necessary to properly expose the CCD.

Elimination of parallax distortion and providing adequate resolution are critical for optical systems which capture fingerprints. For example, if the fingerprint image is keystoned, it is skewed with respect to fingerprints it is being compared against. The skew makes it almost impossible to compare the two images. Additionally, if the resolution is too low, the image will be smudged, which is also virtually useless in comparing fingerprints.

Parallax distortion can be solved either optically, or by computer enhancement. It is understood that most law enforcement agencies throughout the world require that the parallax distortion be corrected optically. In some finger printing devices of the prior art, parallax distortion is minimized through the use of a slanted CCD array in combination with a lens having a high f-stop and an anamorphic prism. Specifically, the CCD array is slanted to the objective distribution plane of the prism. The objective distribution plane is positioned at an angle equal in magnitude but opposite in phase from the plane in which the clearest focus is possible. The image achieved in the objective distribution plane does not include significant parallax distortion. However, a drawback in positioning the CCD array in the objective distribution plane is that a greater depth of field is necessary to achieve acceptable resolution. Therefore, a greater f-stop is required to achieve a greater depth of field which in turn requires more illumination. The anamorphic prism is used to properly orient the image for reception by the CCD array.

The devices disclosed in United States Patent Nos. 4,933,976 and 5,230,025 could be utilized to capture the image of a palm print at great financial expense. Because the palm is of much greater surface area than a finger, a CCD array including a much larger configuration would be necessary to capture the palm print image. These larger CCD arrays are substantially more expensive than those utilized by United States Patent Nos. 5,230,025 and 4,933,976. For example, MEGAPLUS array manufactured by KODAK, having a 2,000 x 2,000 array, would have adequate capacity to produce the required resolution needed for a palm print. However, such CCD arrays cost almost as much as entire commercial systems for capturing fingerprints.

Further, to eliminate parallax distortion and gain the required resolution in a system of the prior art, if it was large enough to capture the image of a palm, the f-stop would need to be substantially increased with a corresponding increase in illumination. However, if f-stop is increased too far, the entire image will fall out of focus. Assuming an acceptable focus was possible, the level illumination required to capture the image of a palm with a very high f-stop would require considerable energy and probably would cause thermal problems.

Despite increased costs associated with capturing a palm print through utilization of the methods and apparatus disclosed in United States Patent Nos. 4,933,976 and 5,230,025, a need exists to provide a method and apparatus for digitizing the image of a palm.

The prior art has provided limited devices and methods to scan palm prints. One such device is disclosed in United States Patent No. 4,032,889 to Nassimbene and assigned to International Business Machines Corporation. United States Patent No. 4,032,889 utilizes photocells to capture the image of a palm. The photocells used in U.S. Patent No. 4,032,889,

as well as the method taught by U.S. Patent No. 4,032,889, are basic methods which may be useful in comparing two different palm prints, but lack other desirable characteristics. For example, the device disclosed in United States Patent No. 4,032,889 does not provide the necessary resolution to print an image of a palm print, a task often required by law enforcement agencies.

Therefore, a need has arisen to provide a device and method for digitizing the image of a palm which solves these and other problems of the prior art.

Summary of the Invention

The present invention relates to an apparatus for eliminating keystone distortion in an image. The image is dividable into a plurality of linear segments where each of the segments has an associated length. The apparatus includes a lens operative in selectively magnifying each of the segments of the image by a different amount as to create a plurality of magnified lines of equal length. A medium operable in being selectively exposed by one of the magnified segments is also included. In the first preferred embodiment, the medium is a fixed horizontal distance from the lens.

The first preferred embodiment of the present invention is an apparatus for generating digital data characteristic of a palm. The apparatus includes a prism including a receiving surface and an object surface. The receiving surface receives the palm. The palm is dividable into a plurality of linear segments. A source of light illuminates the receiving surface so that an image representative of the palm is propagated from the object surface. The propagated image includes a plurality of linear segments corresponding to the linear segments of the palm. Each of the segments of the propagated image includes an associated length. A medium for capturing the image of the palm is movable

between a plurality of locations relative to the object surface of the prism as to capture each of the segments of the propagated images at a different location.

The first preferred embodiment may also include a lens operable in magnifying the segments of the propagated image so that they are all of equal length.

Brief Description of the Drawings

Figure 1 is a block diagram representation of a system which can be used to generate rolled palm print images in accordance with the present invention.

Figure 2 is a diagrammatic side view of the palm print device of the first preferred embodiment of the present invention.

Figure 3 is a diagrammatic view of an image recorder of the first preferred embodiment.

Figure 4 is a side view of a hollow prism.

Figure 5 is a diagram of a palm including a plurality of segments.

Figure 6 is a side view of a fingerprint device included with the palm print device of Figure 2.

Figure 7 is a side view of the palm print device of the second preferred embodiment.

Figure 8 is a cut-away of Figure 7 taken along the line 8-8.

Figure 9 is a side view of the device of Figure 7 with a palm being rolled.

Figure 10 is a cut away of a cylinder in the second preferred embodiment showing a light and an image recorder within the cylinder.

Figure 11 is a side view of a palm being rolled across the device of Figure 7.

Detailed Description of the Preferred Embodiments

In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings which form a part hereof, and which is shown by way of illustration, specific embodiments in which the invention may be practiced. It is to be understood that the other embodiments of the invention may be utilized and structural changes may be made without departing from the scope of the present invention.

To understand the concept behind the invention, one can divide the palm image into a plurality of linear segments so that the parallax distortion may be characterized by segments having different lengths and widths. The segments are spaced between a far segment at one end and a near segment at the other end. The far segment is the furthest from the lens while the near segment is the closest to the lens. Parallax distortion is created because the different segments of the image are subject to different magnifications within the prism, thereby creating segments having different dimensions, i.e. length and width. The different dimensions are eliminated by selectively adjusting the magnification of the lens relative to each segment of the image so that each segment includes the same dimensions.

The prism of the present invention includes a palm receiving surface and a object surface. The palm is placed upon the palm receiving surface. The object surface is the surface of the prism from which the image of the palm is projected. The object surface is slanted with respect to the palm receiving surface. Because the object surface is slanted with respect to the palm receiving surface, light reflected from different portions of the palm, i.e. the far segment relative to the near segment, must travel different distances within the prism before being projected. The different

distances the light must travel creates parallax.

While not being bound to any particular theory, the present invention focuses on the length of the linear segments rather than their width. It may be assumed that the different lengths associated with different segments of the palm creates the parallax distortion. Parallax distortion may be eliminated by magnifying each linear segment of the palm by a different amount and making them the same length. For example, the near segment may be magnified so that its length is the same as the far segment. All of the segments may then be added to create an image of a palm print. The added segments may then be processed, according to the methods of either U.S. Patent Nos. 4,933,976 or 5,230,025, both of which are incorporated by reference.

In the first preferred embodiment of the present invention a linear CCD array travels along a predetermined angled vector relative to a prism. The vector includes vertical and horizontal components. Specifically, a lens moves horizontally relative to the prism while maintaining a constant horizontal distance from a CCD. A CCD moves vertically relative to the lens. The linear CCD array is capable of only capturing one segment of the palm image at a time. For each segment of the palm image being captured, the lens and linear CCD array are repositioned relative to the prism. By repositioning the lens and the CCD array, different segments of the palm image may be magnified by different amounts. By magnifying the segments of the palm image different amounts, segments of otherwise unequal length can be made equal.

The invention also provides a movable light source which illuminates only that portion of the prism corresponding to the portion of the palm, the image of which is being captured. The movable light source preferably includes a light bar and a mirror positioned

on a movable arm. The mirror reflects light into the prism at different locations dependent upon the position of the arm. In the preferred embodiment, the palm printer also includes, in combination, a fingerprint capture device.

According to the first preferred embodiment of the invention, the lens and linear CCD array will be closer to the prism when the near segment is captured, thereby providing increased magnification for that segment, and the lens and CCD array will be farther away when the far segment is captured, thereby providing less magnification. A standard length for a segment of the image may be chosen, and each segment of the image may then be scanned individually and magnified by a different amount so that each segment has the same length when projected onto the CCD.

The second preferred embodiment of the present invention optically eliminates parallax distortion by providing a clear cylinder over which a palm may be rolled. The second preferred embodiment utilizes a linear CCD array in a fixed position relative to the cylinder. Parallax distortion is not an issue in the second preferred embodiment because the portion of the palm in contact with the clear cylinder, as it is rolled across the cylinder, is a constant distance away from the lens and CCD array.

A palm print system 10 which can be used to optically produce palm print images in accordance with the present invention is illustrated generally in Figure 1. Palm print system 10 is a microprocessor-based system which includes processor 12 and associated random access memory (RAM) 14 and read only memory (ROM) 16. Image recorder 22, digitizer 24, video monitor 26, alarm 30, printer 28, and terminal 18 are interfaced into processor 12. The palm print images are captured by utilizing a prism 250. Prism 250 includes a receiving surface 256 and an object surface 258.

A palm is placed in contact with receiving surface 256 which is illuminated, and an image is propagated from object surface 258 which is imaged by recorder 22 and digitized by digitizer 24. Specifically, a light source 200 is directed through prism 250 and reflects off of receiving surface 256. Through the principle of total internal reflection those portions of a palm in contact with receiving surface absorb light and those portions of the palm not in contact with receiving surface reflect light. For example, a valley or crease in the palm will reflect light, while a ridge of the palm will absorb light. The reflected light is propagated from object surface 258 and is characteristic of the image of a palm. The image of the palm is projected towards image recorder 22. An array of digital data representative of the palm print image is provided to processor 12.

Image recorder 22 generally includes a lens, a shutter mechanism, and a recorder medium for controlled recording of palm print images. Terminal 18 includes a keyboard (not separately shown) which is used by an operator to interface with palm print system 10. Palm print images generated by system 10 can be displayed on video monitor 26 or printed onto a standard palm print card by printer 28. Alarm 30 is activated when a palm print is not properly captured, providing the operator with an indication that the capture procedure must be repeated. Systems operative in optically digitizing a fingerprint are disclosed in commonly assigned Fishbein et al. U.S. Patent No. 4,933,976, and Fishbein et al. 5,230,025, the specification and drawings of which are hereby incorporated by reference.

The first preferred embodiment of the present invention is diagrammatically shown in Figures 2 and 3. Figure 2 includes a prism 250 positioned to receive a palm. Prism 250 is large enough to receive the entire palm surface. In the first preferred embodiment,

receiving surface is at least 144 square centimeters although larger receiving surfaces are also contemplated.

With reference to Figure 4, and in an alternative embodiment, prism 250 may be hollow with sidewalls constructed from plexiglass. The prism may be filled with a clear fluid having a refractive index ranging from approximately 1.1 to 4.0, although an index above 1.5 is preferred.

Referring to Figure 5 there is generally shown a palm which has been divided into a plurality of segments, 1 through N. Segment 1 represents the segment closest to the lens, while segment N represents the segment farthest from the lens. Absent the present invention, when imaged through a prism segment N will be disproportionately longer than segment 1.

The mechanism of the present invention positions image recorder 22 such that each segment, 1 through N, is the same length when recorded. With reference back to Figures 2 and 3, image recorder 22 includes a lens 110 and a high-latency linear CCD array device 120 adapted to receive images over the desired period of time. Lens 110 is preferably a 60mm lens, available from a variety of manufacturers, for example Thompson Composants Militaires et Spatiaux of France or Dalsa of Waterloo, Ontario. In the preferred embodiment CCD array device 120 is purchased from Dalsa as a Dalsa CCD array model CL-C73456. Referring specifically to Figure 3, lens 110 is rigidly held into place by an image recorder frame or carriage 121. Carriage 121 is slidably positioned on gear bar 102 which is positioned proximate prism 20. Gear bar 102 is engaged to a linear stepper motor 140 operable in moving carriage 121 horizontally toward and away from prism 250, along gear bar 102, as best illustrated in Figure 2. The segments of the image are magnified by moving the lens toward and away from the prism.

Stepper motor 140 is configured to receive digital input from a processor (not separately shown) so that it may be precisely controlled. Such motors are commercially available from THK, as model 306K. Lens 110 is rigidly fixed to carriage 121 and operates to magnify each segment of the palm a different amount as it moves toward and away from prism 250. The rate at which carriage 121 moves is dependent upon the sensitivity of linear CCD 120. Typical scan rates in the present invention may be 220 μ per line.

As best shown in Figure 3, linear CCD 120 is positioned a fixed horizontal distance from lens 110. In the first preferred embodiment, CCD 120 is slidably positioned on a vertical rail 122 of carriage 121. Specifically, CCD array 120 is connected to a rolling guide 124 on vertical rail 122 so that CCD 120 may move up and down vertical rail 122. The top of guide 124 is hinged to a slanted rail 126. Slanted rail 126 is in a fixed position relative to gear bar 102. As carriage 121 moves toward and away from prism 250 along gear bar 102, rolling guide 124 and CCD array 120 move up and down vertical rail 122. In this fashion, CCD array 120 is at a different vertical position for each different horizontal position of carriage 121.

Moving CCD array 120 up and down as carriage 121 moves horizontally toward and away from prism 20 defines an angled vector at an angle θ. Angle θ is determined by the configuration of prism 250. Specifically, angle θ is determined by the refractive index of the prism material and in the first preferred embodiment is 47°.

The present invention provides significant advantages. Utilization of a linear CCD array 120 is significantly cheaper than the two dimensional CCD arrays of the prior art. This is especially true because of size limitations placed on two dimensional CCD arrays large enough to capture the image of a palm.

Further, by moving the CCD array up and down the CCD can be positioned at the focal point of the lens for any given segment of the palm which is being captured. By continuously positioning the CCD array at the focal point of the lens, the f-stop of the lens does not need to be very high to obtain the proper resolution. Additionally, the illumination requirements are minimized which in turn decrease power requirements of the device.

It is to be understood that the image segments may be magnified using a variety of other techniques. For example, instead of moving the lens toward and away from the prism as described above, the lens may be of the telephoto variety magnifying the image segments by rotating the telephoto mechanism. Also, the medium, or CCD could be moved toward or away from a lens where the lens is a fixed distance from the prism.

In the first preferred embodiment a movable light source 200 is provided. With reference to Figure 2, movable light source 200 illuminates approximately a single segment of the palm on receiving surface 256. Specifically, light source 200 illuminates a different portion of receiving surface for each different position of carriage 121. In the first preferred embodiment, light source 200 is a quartz rod 202. As best seen in Figure 2, quartz rod 202 projects light toward a mirror 206 positioned on an arm 204. Arm 204 is mounted to a guide 208 which in turn is received on a rail 210 so that arm 204 and guide 208 are movable thereon. As arm 204 moves on rail 210, arm 204 rotates through approximately 7°. Arm 204 rotates so that light is reflected toward receiving surface 256. Specifically, arm 204 is driven along rail 210 by a second stepper motor 214. Mirror 206 has a length sufficient to project light across the width (corresponding to the length of the segment of the palm) of prism 250. As shown by phantom line 275 in Figure 2, light reflects

off of mirror 206 and into prism 250. In an alternative embodiment, arm 204 may be replaced with a cam (not shown) rotatable about 7 degrees and movable along rail 210. Quartz light 202 may be replaced with a fiber optic light source.

In the first preferred embodiment, the data captured by CCD array 120 is delivered to digitizer 24 and processor 12 each time the lens moves. The rate at which carriage 121 reciprocates horizontally toward and away from prism 250 is a function of the sensitivity of CCD array 120 and the strength of light source 200. The preferred embodiment includes scan rates of approximately 220 μ per line. A scan is defined by the time it takes CCD array 110 to gather the information from a segment of the image of the palm print propagated from object surface 258. As the information is gathered by CCD array 120, it is integrated together to process an image of the palm print. The integration can occur "piece meal" as the information is gathered and then the integrated pieces can be integrated together, or, the integration may be over the entire time required to gather the information representative of the palm print. However, operation under both methods require that CCD array 110 be cleared prior to each segment of the palm being captured. The methods for capturing a palm print through the above-described methods are described in commonly assigned U.S. Patent Nos. 4,933,976 and 5,230,025, respectively, which have been previously incorporated by reference.

In operation, a palm is placed on receiving surface 34 of prism 20, and quartz light 202 projects light which is reflected off mirror 206. Mirror 206 reflects light onto a limited portion of the receiving surface 256 such that a single portion of the palm is illuminated. Through the principle of total internal reflection, light images representative of that portion of the palm print will pass through lens 110 and will be

focused onto CCD array 120. By selectively positioning carriage 121, including lens 110, each segment of the palm will be magnified by a different amount such that their lengths will be a constant value. CCD array 120 is oriented such that it is at the focal point of lens 110 relative to any given segment of the palm which is being captured. Arm 204 repositions mirror 206 so that each time carriage 121 is repositioned, mirror 206 is repositioned to illuminate a different portion of receiving surface. For example, if segment 1 of palm, as shown in Figure 5, was captured initially, carriage 121 and thereby lens 110 would move forward towards prism 250 and CCD array 120 would move upward relative to lens 110. Correspondingly, arm 204 and mirror 206 would be also repositioned. By positioning lens 110 closer to prism 250 when segment 2 is captured, segment 2 is magnified a greater amount than the segment 1. The difference in magnification is such that the segments are the same length. CCD array 120 is moved vertically upward because the focal point of lens moves upward when capturing the second segment. This process continues until the entire palm print is captured.

The digital information gathered by CCD array 120 will then be integrated according to the methods disclosed in U.S. Patent Nos. 4,933,976 or 5,230,025, both of which have been previously incorporated herein by reference. Once the image of the palm print has been processed, it can be transmitted to monitor 26 for visual inspection or to printer 28. If the image is not satisfactory, alarm 30 will sound and the palm print can be taken again.

With reference to Figure 6, the preferred embodiment of the present invention may also include, in combination, a device for optically capturing the image of a fingerprint.

The fingerprint device includes two lenses 100 and 101 positioned adjacent one another operating to

focus the image of a finger onto two separate, two dimensional CCD arrays, 110 and 111. CCD arrays 110 and 111 gather light and convert it into a digital data representative of the fingerprint. Data gathered by CCD arrays 110 and 111 is then integrated separately or integrated in its entirety according to the methods disclosed above, which are in accordance with commonly assigned U.S. Patent Nos. 4,933,976 and 5,230,025, which have been previously incorporated by reference.

Each lens 100 and 101 needs to be adjusted so that there is a slight overlap of data gathered by each CCD array 110 and 111. The overlap is then compensated for by techniques known in the art, and the images are integrated together.

The second preferred embodiment of the invention is disclosed in Figures 7-10. With initial reference to Figures 7 and 8, the second preferred embodiment utilizes a clear cylindrical tube 400. As shown in Figure 9, a palm can be rolled across clear cylinder 400 in order to capture the image of the palm. Cylinder 400 includes a cylindrical surface 402. As best shown in Figures 7 and 8, the palm capturing device of the second preferred embodiment also includes an encoder 410, an image recorder 422 and a light 440. Image recorder includes a lens and a CCD.

The palm printer of the second preferred embodiment also utilizes the principle of total internal reflection. As best shown in Figure 8, light reflects through cylindrical surface 202 at an angle α. Places where the palm is in contact with cylinder surface 402 of cylinder 400 absorb light, while those portions of the palm which are not in contact with skin reflect light. In operation, the palm is rolled over cylinder 400 either in a frontways or a sideways configuration as best shown in Figures 9 and 11.

Clear cylinder 400 is rotatable about an axis 404. Clear cylinder 400 may include two open ends

having a lumen therebetween, or may be of solid construction. Clear cylinder 400 may be rotated by a motor 406. If cylinder 400 is rotated by motor 406, cylinder 400 will pull the palm across it. If no motor is utilized, clear cylinder 400 will rotate in response to the palm being drawn across it.

As the hand is rolled across cylinder 400, light propagated from light source 440 will reflect or be absorbed relative to that portion of the palm in contact with cylinder surface 202 of clear cylinder 200. The reflected light is captured by recorder 422 which is fixed in position relative to cylinder 400. CCD array 430 then communicates the data to a digitizer and a processor in a similar manner or described above.

The processor then correlates the amount of rotation determined by encoder 410 against the data collected from CCD array 230 and integrates that data in accordance with the method of either U.S. Patent Nos. 4,933,976 or 5,230,025. The image may then be used in the same fashion as disclosed above.

Image recorder 422 may be positioned within the clear cylinder, as shown in Figure 10, or external to cylinder 400, as shown in Figure 8. If image recorder 422 is positioned within the cylinder, mirrors 450 are required to increase the distance which the reflected light travels so that the proper resolution is achieved.

In the second embodiment, the curved surface which receives the palm provides easy operation as the palm can be rolled across the cylinder. The edge of a palm may also be captured by taking a second roll of the edge of the palm and integrating it with the first. Each system also includes the advantages of both the 4,933,976 and 5,230,025 patents insofar as those patents describe the general nature of the method used to process the fingerprint.

While the foregoing detailed description of the present invention describes the invention of the preferred embodiments, it will be appreciated that it is the intent of the invention to include all modifications and equivalent designs. Accordingly, the scope of the present invention is intended to be limited only by the claims which are appended hereto.

WHAT IS CLAIMED IS:

1. An apparatus for capturing an image, said image dividable into a plurality of segments, each of said segments having an associated length, said apparatus comprising:

a lens operative in selectively magnifying each of said segments of said image a different amount, as to create a plurality of magnified segments having a substantially equal length;

a medium operable in being selectively exposed by one of said magnified segments.

2. An apparatus as in claim 1 wherein said medium is a fixed horizontal distance from said lens.

3. An apparatus as in claim 1 wherein said medium is a CCD array.

4. An apparatus as in claim 3 wherein said CCD is a single dimension CCD operable in moving through a plurality of positions as to capture each of said magnified segments.

5. An apparatus as in claim 1 wherein said image is of a palm.

6. An apparatus as in claim 5 further comprising:

a prism having a palm receiving surface and an object surface, said receiving surface constructed and arranged to receive said palm;

a light source operative in illuminating said palm receiving surface of said prism so that an image representative of said palm is propagated from said object surface.

7. An apparatus as in claim 6 wherein said light source is constructed and arranged as to selectively illuminate said palm receiving surface of said prism so that only a portion of said image of said palm is projected from said imaging surface, said portion of said image including at least one segment of said image and said lens positioned to magnify said segment and said medium being exposed by said magnified segment.

8. An apparatus as in claim 7 wherein said light source further comprises linear illumination means, which directs light at a mirror selectively positionable to illuminate discrete portions of said palm receiving surface.

9. An apparatus as in claim 1 wherein said lens comprises a telephoto lens selectively positionable between a plurality of different magnification levels.

10. An apparatus for generating digital data characteristic of a palm as in claim 1 wherein said lens magnifies each of said plurality of segments by moving toward and away from said prism and said lens maintaining a constant distance from said medium.

11. A method for capturing an image of an object, said image dividable into a plurality of segments, each of said segments having an associated length, said method comprising:

selectively magnifying each of said segments of said object a different amount with a lens, as to create a plurality of magnified segments having a substantially equal length;

selectively exposing a medium with said magnified segments one segment at a time.

12. A method as in claim 11 further wherein said image is magnified by moving said lens toward and away from said object.

13. A method as in claim 11 wherein said image is propagated from a prism, said method further comprising the step of:

illuminating said prism with a light source.

14. An apparatus for generating digital data characteristic of a palm comprising:

a prism including a receiving surface and an object surface, said receiving surface constructed as to receive said palm, said palm including a plurality of segments;

a source of light operable in illuminating the receiving surface so that an image representative of said palm is propagated from the object surface, said propagated image including a plurality of segments corresponding to said segments of said palm, said segments of said propagated image including an associated length; and,

an image recorder movable between a plurality of positions relative to the object surface of the prism as to capture each of said segments of said propagated image at a different location.

15. An apparatus as in claim 14 wherein said image recorder comprising a lens and a medium, said lens and said medium spaced away from said object surface such that said lens is positioned between said object surface and said medium, said lens operable in selectively magnifying said segments of said propagated image by different amounts such that said segments are of equal length.

16. An apparatus as in claim 15 wherein said lens is positioned on a carriage; said carriage movable on a base, and said carriage mobile toward and away from said object surface as to magnify said segment of said propagated image.

17. An apparatus as in claim 16 wherein said base is a gear bar.

18. An apparatus as in claim 17 wherein said medium is a positioned a fixed horizontal distance from said lens and said medium vertically reciprocates relative to said lens.

19. An apparatus as in claim 18 wherein said medium is positioned on a roller guide slidably engaged against a vertical rail, said vertical rail fixed to said carriage; said roller guide slidably engaged to a slanted rail, said slanted rail fixed relative to said gear bar.

20. An apparatus as in claim 15 wherein said lens is a telephoto lens operable in selectively magnifying segments of the image.

21. An apparatus as in claim 14 wherein said prism includes a lumen filled with an liquid having a refractive index above 1.1.

22. An apparatus as in claim 14 further comprising a second prism operable in receiving the surface of a finger, and a second digitizer operable in digitizing an image of a fingerprint.

23. An apparatus as in claim 14 wherein said light source further comprises a mirror positioned on an arm, said arm slidably received on a rail, said light source

constructed an arranged to illuminate said mirror so that said mirror reflects light onto a discrete portion of said receiving surface of said prism.

24. An apparatus as in claim 23 wherein the light is a high intensity light.

25. An apparatus for generating digital data characteristic of a palm comprising:

a) a transparent cylindrical member rotatable about an axis, the cylindrical member including a top outer surface operable in receiving the palm;

b) a light source operable in illuminating the top outer surface of the transparent cylinder, the light source positioned so that light is reflected from the top outer surface; and

c) a digitizer positioned to receive the reflected light; the digitizer operable in generating an array of digital data characteristic of the palm.

26. An apparatus as in claim 25 further comprising an encoder for measuring the amount the transparent cylinder has rotated, the encoder operably connected to the digitizer.

27. An apparatus as in claim 26 wherein the cylindrical member further includes a shaft positioned at the axis of the cylindrical member, the shaft being driven by a motor.

28. An apparatus as in claim 25 wherein the cylinder is hollow.

29. An apparatus as in claim 28 wherein the light source is positioned within the cylindrical member.

30. An apparatus as in claim 29 further comprising a plurality of mirrors positioned within the cylindrical member operable in reflecting light to the digitizer.

31. An apparatus as in claim 30 wherein the digitizer is positioned within the cylindrical member.

32. An apparatus as in claim 25 wherein the light source is positioned below the transparent cylindrical member.

33. An apparatus as in claim 32 wherein the digitizer is positioned below the transparent cylindrical member.

34. A method of generating data characteristic of a palm print image, wherein the method comprises the steps of:

providing a cylindrical palm receiving surface which reflects light as a function of a ridge and valley pattern of a palm brought into contact with a palm receiving surface;

providing an image recording medium positioned to receive the propagated light;

rolling a palm across the palm-receiving surface wherein said image of said palm is propagated to said image recording medium;

converting the palm image into digital signals; and

generating an array of digital data characteristic of a complete rolled palm print image from the digital signals.

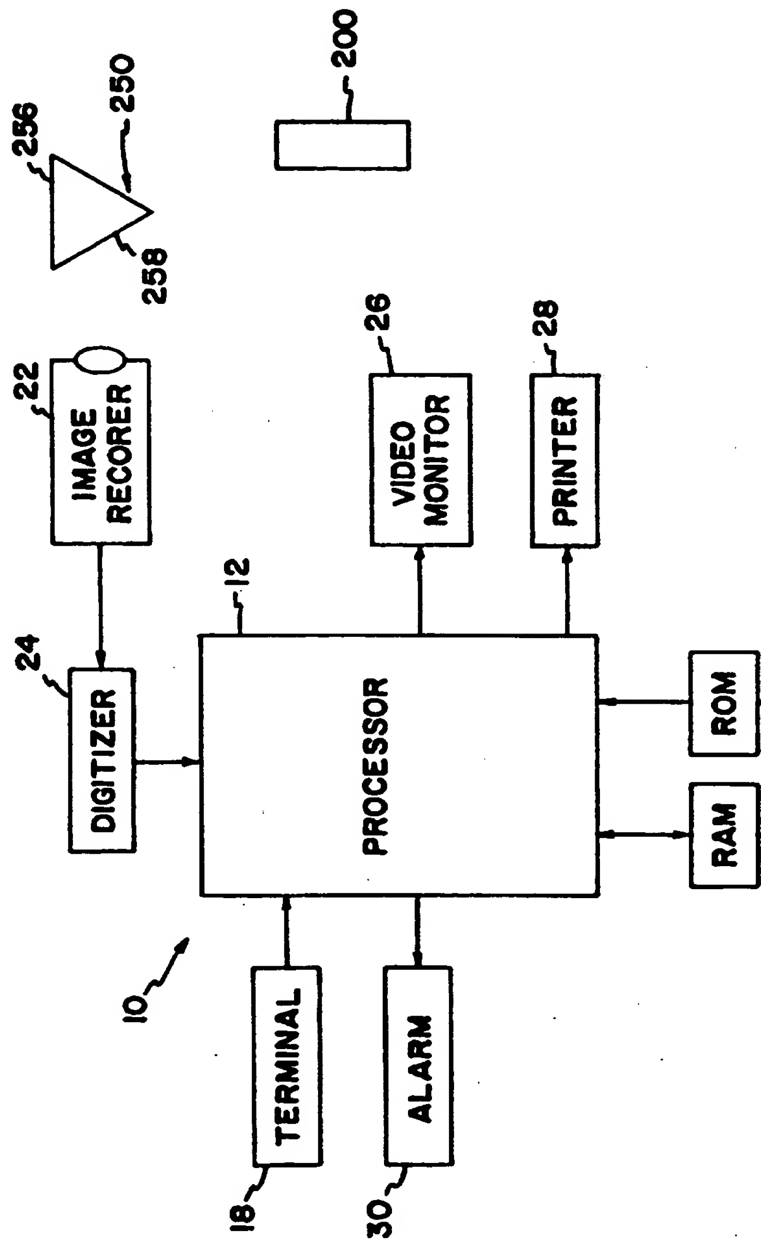
35. The method according to claim 34 wherein the step of generating the array includes generating the array in real time as the finger is being rolled.

36. The method according to claim 34 wherein the step of converting the fingerprint image includes determining a threshold value for the digital data to determine presence or absence of contact of the palm with the palm-receiving surface.

37. The method according to claim 34 wherein the step of converting the fingerprint image comprises:

storing arrays of digital data characteristic of adjacent and overlapping palm print images of portions of the palm as the palm is rolled across the palm receiving surface; and

generating a composite array of digital data characteristic of a rolled palm print image as a mathematical function of overlapping image data from a plurality of arrays and characteristic of the overlapping portions of the fingerprint images.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DIGITIZER
PROCESSOR
VIDEO MONITOR
PRINTER
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RAM
TERMINAL
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FIG. 1

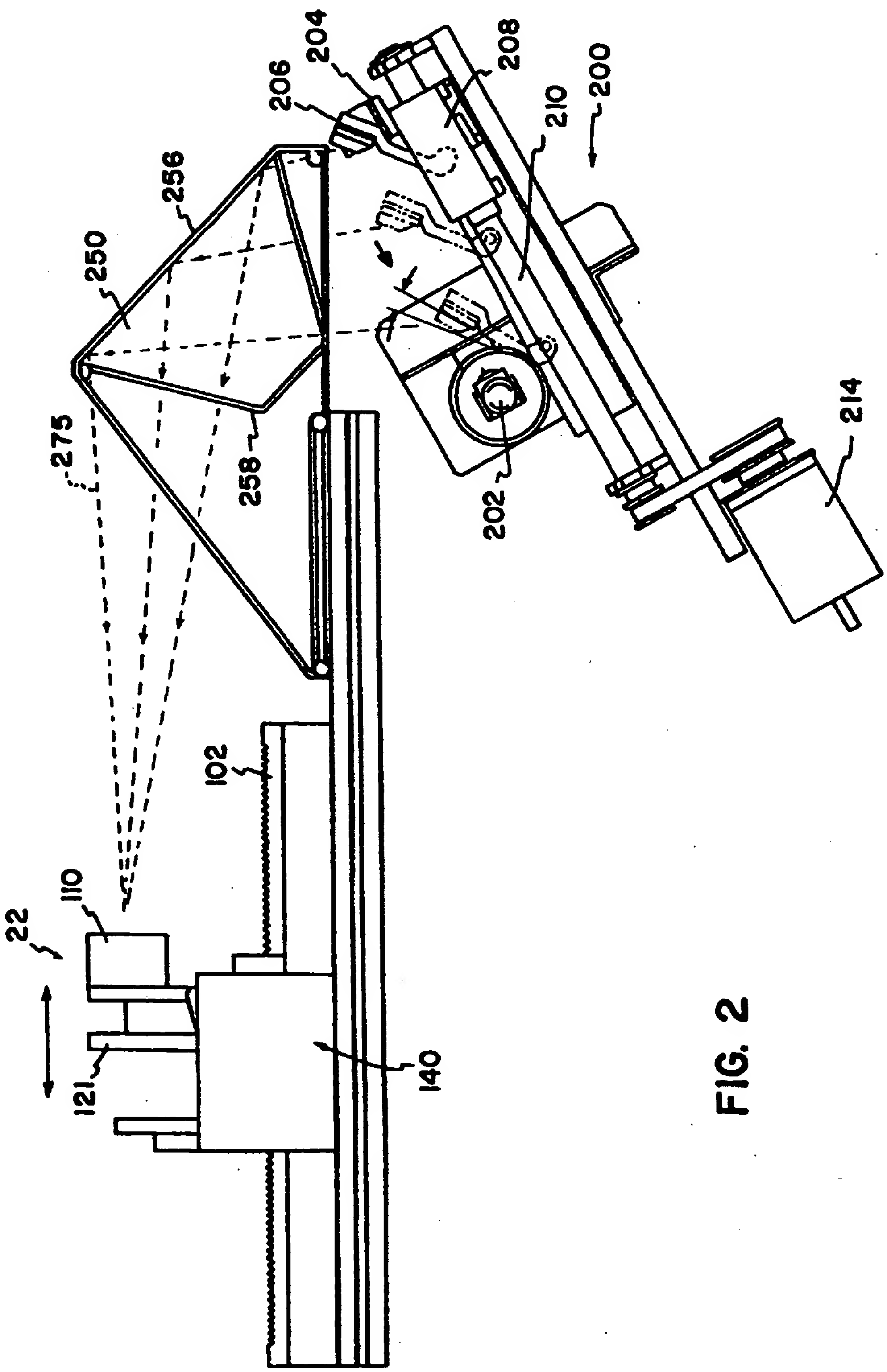


FIG. 2

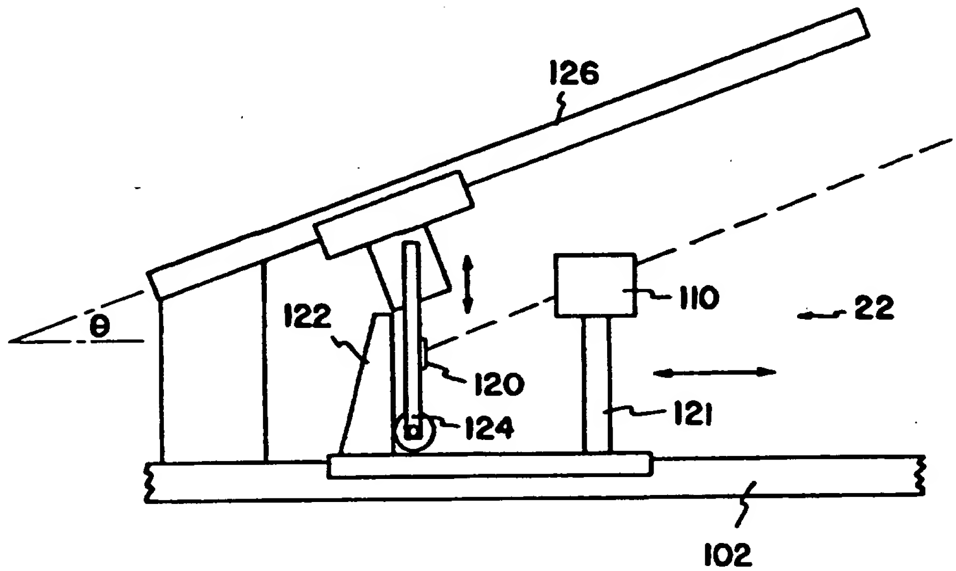


FIG. 3

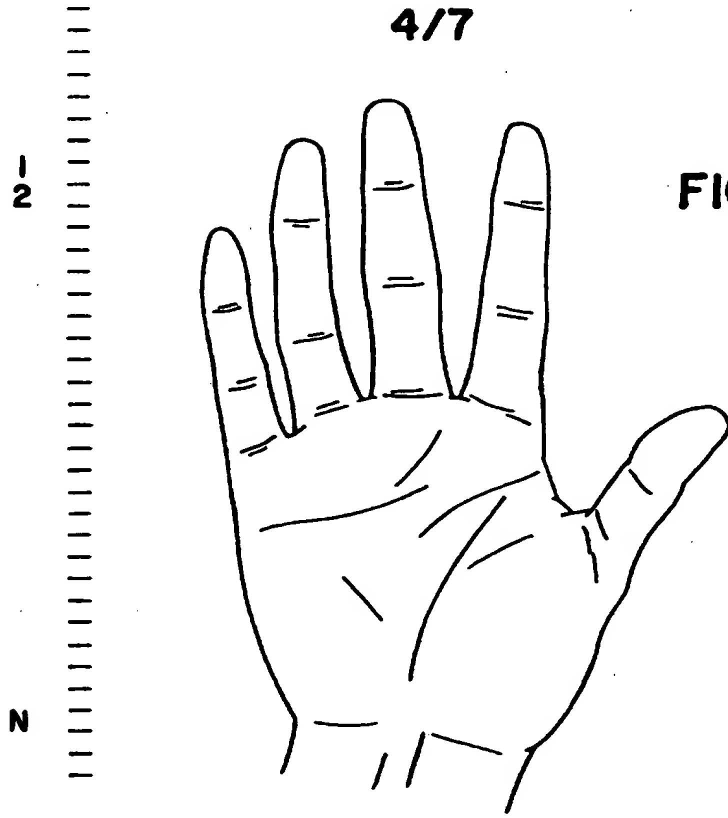


FIG. 5

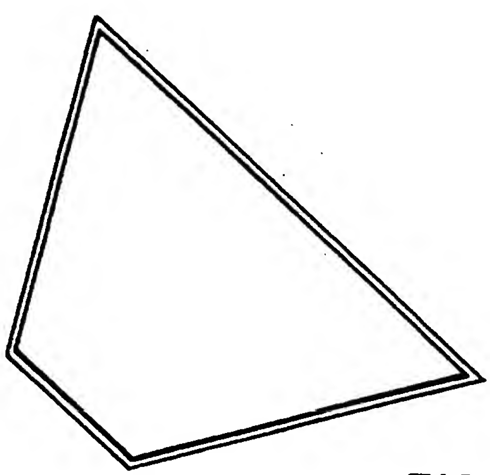


FIG. 4

FIG. 10

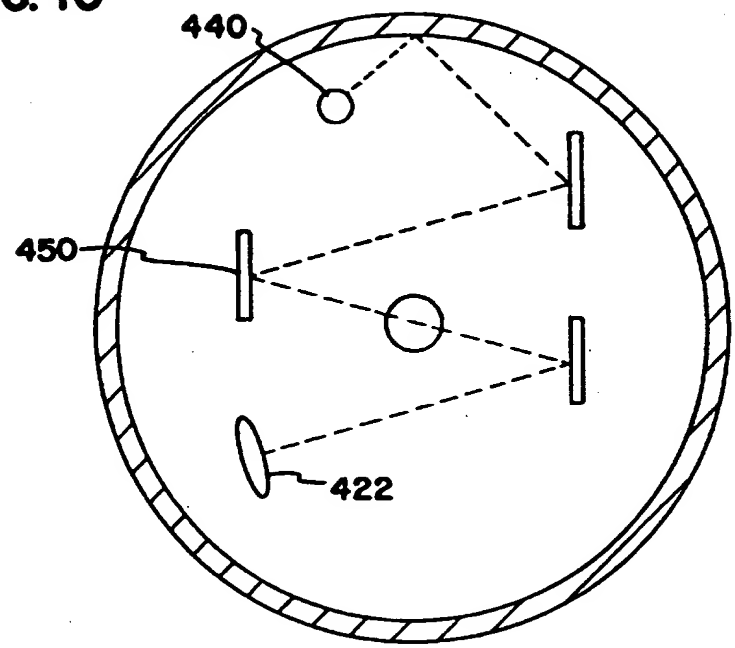


FIG. 6

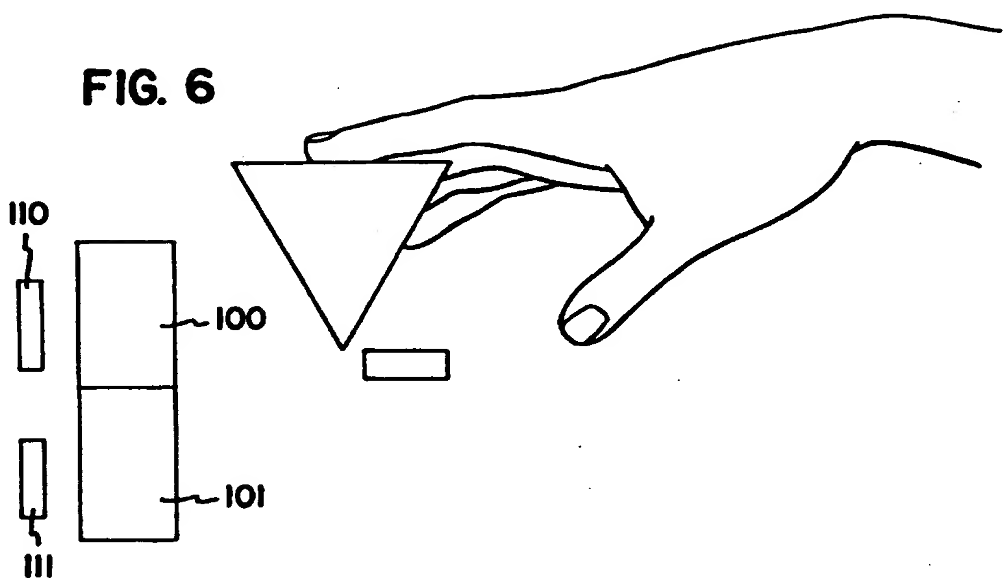


FIG. 9

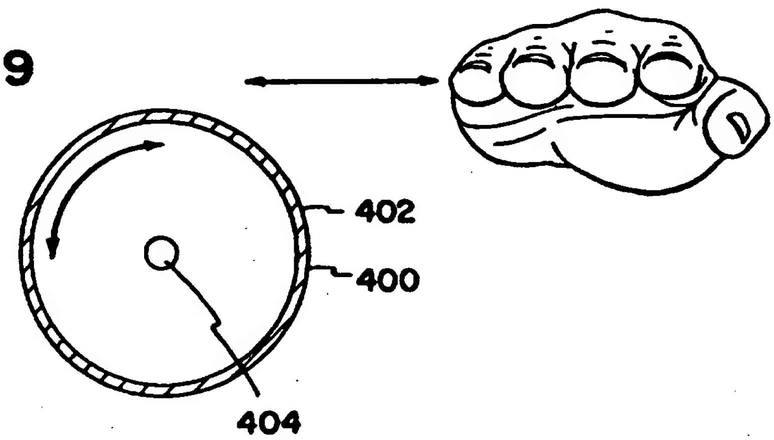


FIG. 7

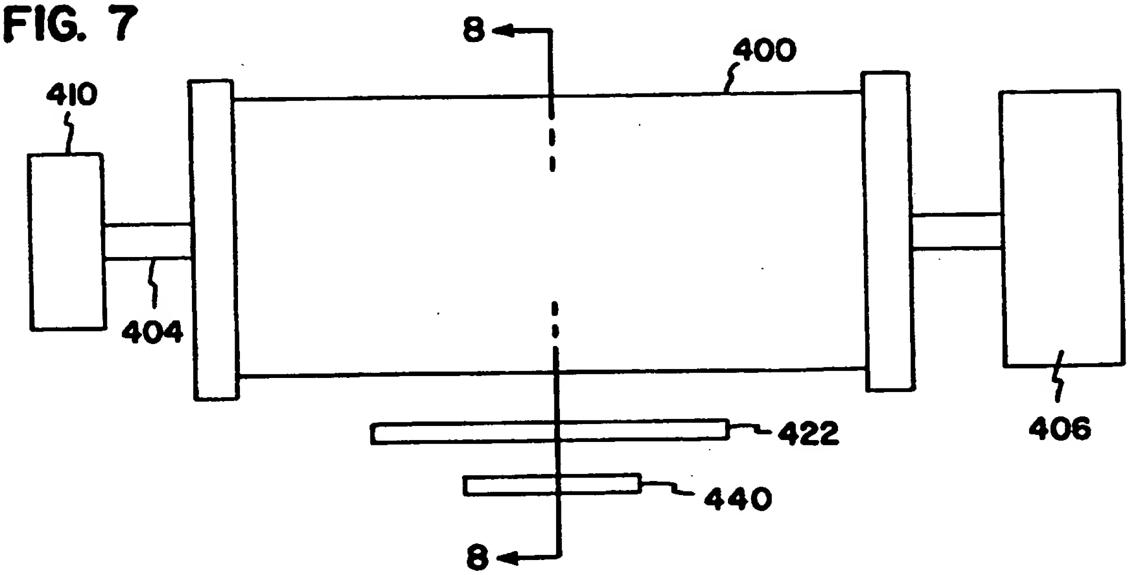
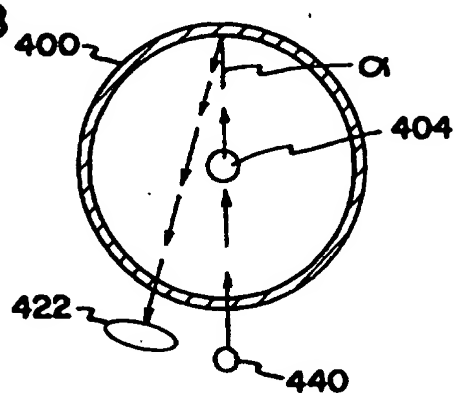


FIG. 8



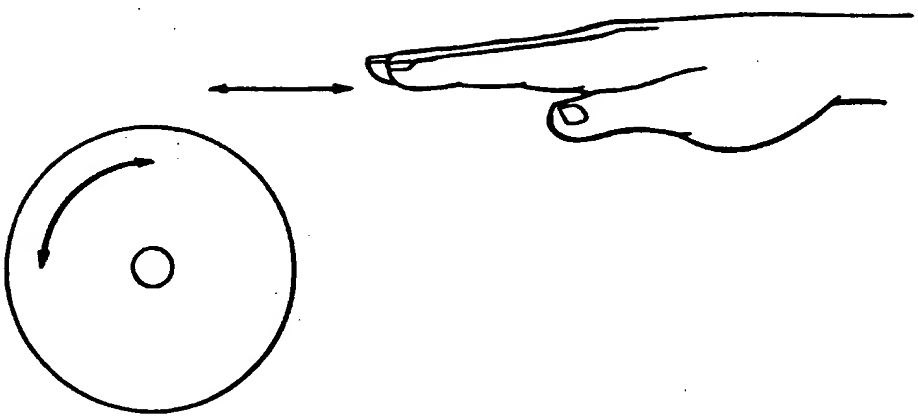


FIG. 11